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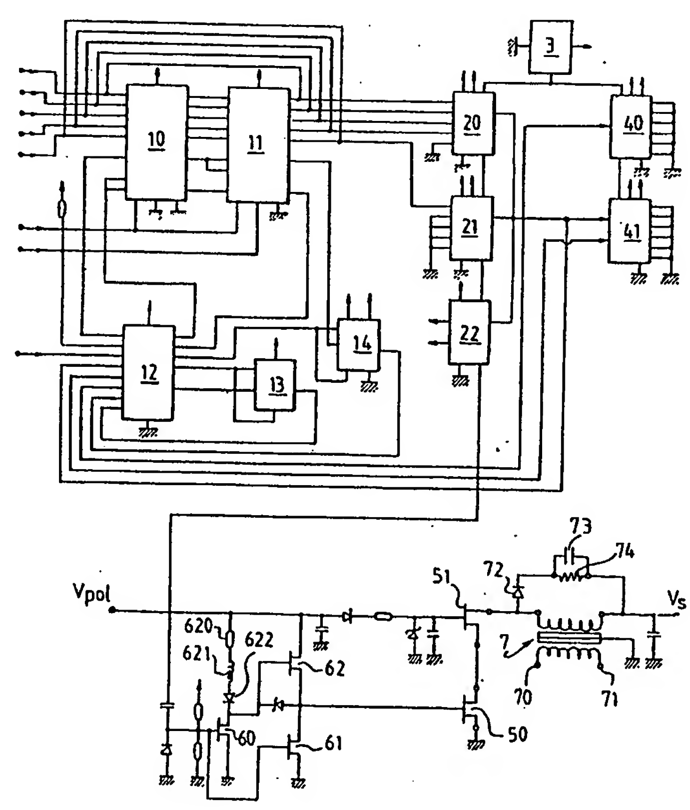
(54) Electrosurgical generator

(57) The generator comprises a clock (3) which supplies logic signals, at the frequency of 56 MHz, to counters (20—21) having a programmable capacity, triggered off at each period of a fundamental frequency of 875 KHz obtained by division (at 40—41) of the clock frequency. Binary programming words for the counter are provided, from a microprocessor, by FIFO registers (10—11) adapted to periodically recycle the modulation sequence. A power amplifier, comprising field effect transistors (50—51), supplies the output signals to a transformer (7). For cutting and coagulating tissues, high frequency signals or pulse width modulated signals having a rise time less than a few tens of nano-seconds are used. The width of the modulated pulse may vary from period to period in dependence upon the input binary data.



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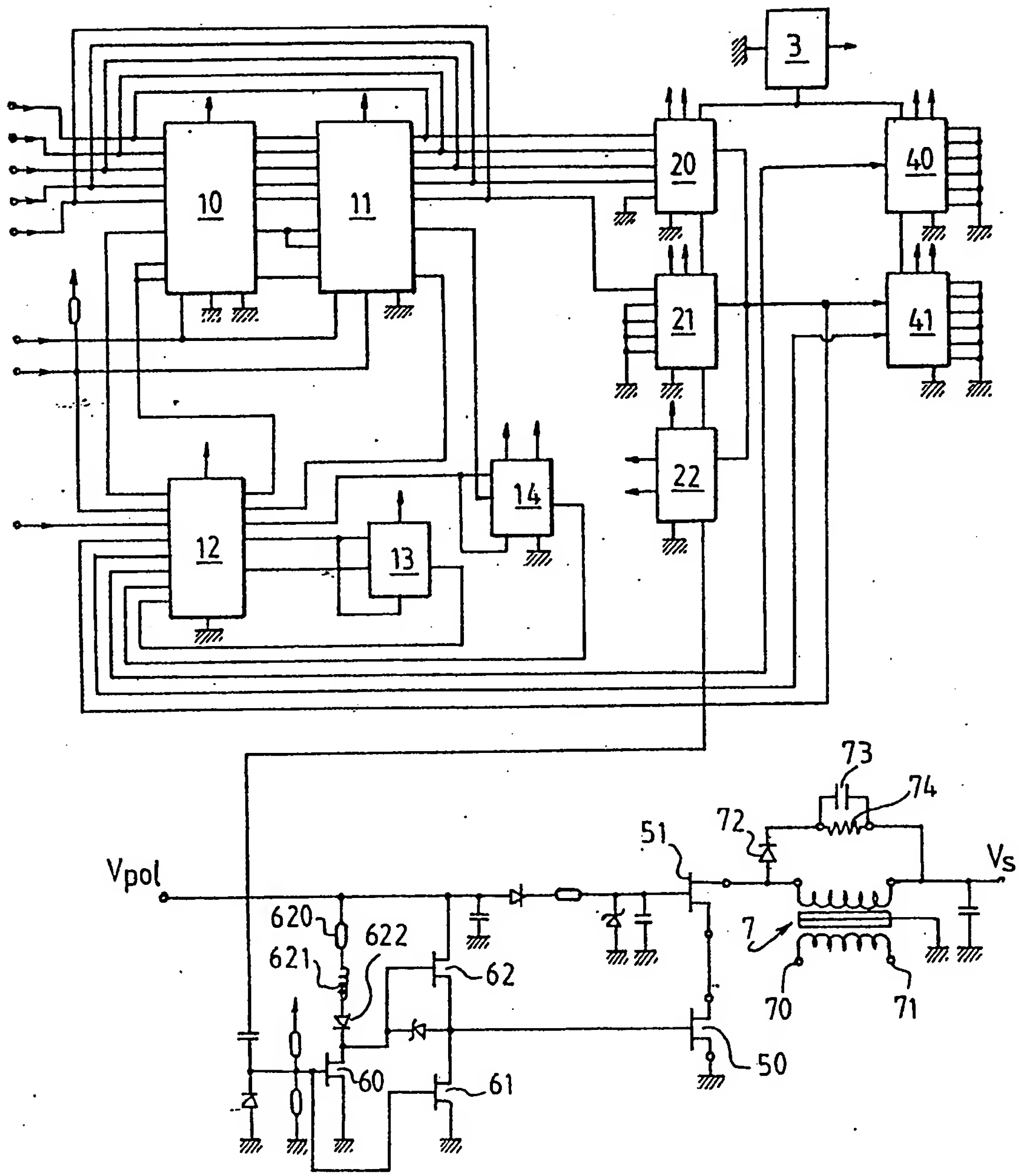
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SPECIFICATION

Generator of rectangular waves with very steep fronts for electro-surgery devices.

Background of the Invention

1. Field of the Invention

The invention relates to electro-surgery and, more particularly, to the generator means which provide the signals applied to the electrodes used for cutting and coagulating tissues.

2. Description of the Prior Art

Present electric surgical devices use, for cutting, currents at a high frequency of the order of several hundred kilohertz and a few megahertz (between 250 KHz and 2 MHz for example). It is a question generally of a pure sustained wave for cutting and, for coagulation or in a mixed mode, possibly a wave modulated at a rate of 80 to 100% for example, by signals having a frequency of about ten or a few tens of KHz.

The waveform of the modulating signals is chosen empirically and varies from one apparatus to another, going from the square or rectangular signal to the sine wave, to the triangular signal or others. The signals, even when they are rectangular, do not have steep fronts, the electric circuits used not transmitting sufficiently high frequencies for this purpose.

The powers generated under pure sustained wave operation are adjustable between 0 and 200 watts for the class of so-called low power apparatus, from 0 to 300 watts for so-called medium power apparatus and from 0 to 400 watts for high power apparatus.

With such high powers, operation when cutting very often produces a zone of necrosed tissue in the region treated by the electrode and an internal underlying zone burnt to a lesser or greater degree: because of this disadvantage, which is important in practice, electrical surgical knives are mainly used for coagulation purposes.

Summary of the Invention

The present invention proposes overcoming this disadvantage to allow sharp cuts to be made of the kind which are obtained in micro-surgery by means of a laser beam.

For that purpose, it is an object of the invention to provide an electro-surgery device which generates and uses rectangular waves having rise times less than a few tens of nanoseconds.

According to a preferred embodiment of the invention, the adjustment of the power supplied by the generator is obtained by pulse width modulation of the rectangular waves by means of a device counting clock pulses at a frequency equal to several tens of MHz, programmable by means of digital data.

In a particularly advantageous embodiment, the digital programming data is supplied, from a microprocessor, by a periodic storage and recycling device, which is advantageously formed by "FIFO" registers.

Brief Description of the Drawings

Other features, and the advantages of the invention will be clear from the following description.

The single figure of the accompanying drawing shows a device for generating rectangular signals with very steep fronts, modulated in width, in accordance with a preferred embodiment of the invention.

Description of the Preferred Embodiment

This device comprises essentially: a microprocessor, not shown, which supplies data words to a periodic storage and recycling circuit formed of elements 10 to 14; a modulator formed of elements 20 to 22; a quartz oscillator 3; a frequency divider formed of elements 40 and 41, a power amplifier comprising two field effect transistors 50—51, preceded by a driver circuit comprising three field effect transistors 60—61—62 and an output transformer 7, to the secondary terminals 70—71 of which the user elements are connected.

Oscillator 3 provides, in the form of rectangular signals with an amplitude of 5 volts for example, a clock frequency C for example equal to 56 MHz, which the dividers 40—41 divide by 64 so as to obtain a frequency of 875 KHz. This is applied to the two stages of programmable counters 20—21 and to the output flip-flop 22 of the modulator. At each period of the fundamental frequency A (875 KHz in the example considered) the counter assembly 20—21 begins to count the clock pulses (at 56 MHz) at the beginning of the period and it feeds a pulse to the output flip-flop 22 when it has reached its maximum capacity, which is programmed, between a value 0 and a value B, equal to 32 in the example described, by the D output bits of element 11 (in the example considered where $B = 32$, $D = 5$). The result is that the modulator supplies, at its output, a square signal whose width may vary from one period to the next, between 0 and 570 ns, by steps of $1/B = 1/32$, depending on the word formed of the five bits mentioned above.

This word is supplied by two FIFO registers 10 and 11 each having a capacity of 16 five bit words, adapted to operate in one of the following three modes:

— a loading mode, where the control words required (at most equal to 32 in number) for determining a complete modulation sequence, which are supplied by the microprocessor depending on the program in use, are introduced into the assembly 10—11;

— a loop mode, during which these words circulate continuously in the two registers at frequency A, so as to produce complete successive sequences;

— finally, a "transparent" mode, where everything takes place as if word 31 were permanently applied to the modulator, so that this latter supplies non-modulated square signals at the fundamental frequency.

The operating mode is determined by the interface circuit, itself formed of FIFO registers 12 to 14 and which receives a control word from the microprocessor. The material construction of this assembly for storing and sequentially reproducing the data controlling the width modulation supplied by the microprocessor will not be described in further detail.

A man skilled in the art may devise different variants of this assembly, its construction with FIFO registers being however particularly simple.

It should be noted that the use of FIFO, or equivalent elements, allows modulation sequences to be obtained as varied and complex as desired, comprising any number of periods of the fundamental frequency A and, possibly, a variation of the width of the rectangular waves from one wave to each following wave.

Since, in practice, the microprocessor used will use components of the CMOS type, which present, among others, the advantage of being little sensitive to the noise generated by the power amplifier, the words may only be modified at a rate of 200 KHz at most, that is to say that the modulation rate would be relatively low in the absence of a device for storing and recycling the data. It should moreover be emphasized that the use of such a device considerably simplifies programming and allows the microprocessor to be made available, during modulation, for carrying out other tasks, such as safety or control of the power.

The unmodulated square signals will generally be used for cutting. For the mixed mode, a sequence will be used for example comprising 8 rectangular waves having a width of 570 ns, followed by 8 rectangular waves of zero width or a width less than 560 ns and, for coagulation, a sequence formed of 16 rectangular waves of a width of 570 ns, followed by 16 rectangular waves of zero width or a width less than 570 ns. These examples of modulation sequences are in no way limiting, the device described allowing any modulation sequences to be obtained at will.

Transistors 60—61—62 and 50—51 are advantageously of the VMOS type: they operate as switches and not in class A, which allows them to keep substantially the steepness of the fronts of the modulated signals. In practice, if the 875 MHz signals supplied by flip-flop 22 have for example rising fronts of the order of 10 ns, the amplified signals will have fronts of the order of 20 ns: experience has shown that such signals are particularly satisfactory for electro-surgery.

The drive circuit 60—61—62 is of a type known per se. The series connection of a resistor 620, an inductance 621 and a diode 622 provides rapid control of the gate of transistor 62 by the derivative of the signal applied to the gate of transistor 60. Transistor 62 ensures discharge of the gate capacity of the VMOS power transistor 50.

In the power amplifier, transistor 51 plays an insulating role and facilitates the gate control of transistor 50.

The circuit formed of diode 72, in series with the circuit formed by capacitor 73 and resistor 74 in parallel, is connected to the terminals of the primary of the output transformer and fulfils the role, in a way known per se, of protecting by recovering, during the disabled times of the transistors, the reactive energy accumulated in the primary during the conducting times.

It goes without saying that different modifications may be made to the circuits described and shown without departing from the spirit and scope of the invention, as defined in the appended claims.

CLAIMS

1. In an electro-surgery device, means for generating rectangular waves, wherein said waves have rise times less than a few tens of nanoseconds.

2. The device as claimed in claim 1, wherein said generating means comprise a clock oscillator at a frequency equal to several tens of MHz, a frequency divider generating square signals at a fundamental frequency which is a sub-multiple of the clock frequency, of the order of several hundred KHz, means for counting, from the beginning of each period of said fundamental frequency, a variable number of clock periods programmed by digital data and means for generating rectangular waves whose width is determined, at each period of the fundamental frequency, by the duration of the counting operation.

3. The device as claimed in claim 2, wherein said digital data is supplied, from a microprocessor, by means for periodically storing and recycling a sequence of binary words.

4. The device as claimed in claim 2, wherein said storage and recycling means comprise FIFO registers and each adapted and controlled so as to carry out, either loading of said sequence, of the circulation in a loop of the words of said sequence in the said means, or the permanent generation of the word which corresponds to the maximum width of the rectangular waves.

5. The device as claimed in one of claims 2 to 4, wherein said clock frequency is equal to 56 MHz and said fundamental frequency is equal to 875 KHz.

6. The device as claimed in one of claims 2 to 5, further comprising means for power amplifying said rectangular waves, said power amplifying means comprising field effect transistors.

7. A generator of rectangular waves with very steep fronts as hereinbefore described with reference to the accompanying drawings.

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